

EMCal simulation

Quick summary and outlook

Jin Huang (BNL)

Simulation tutorial

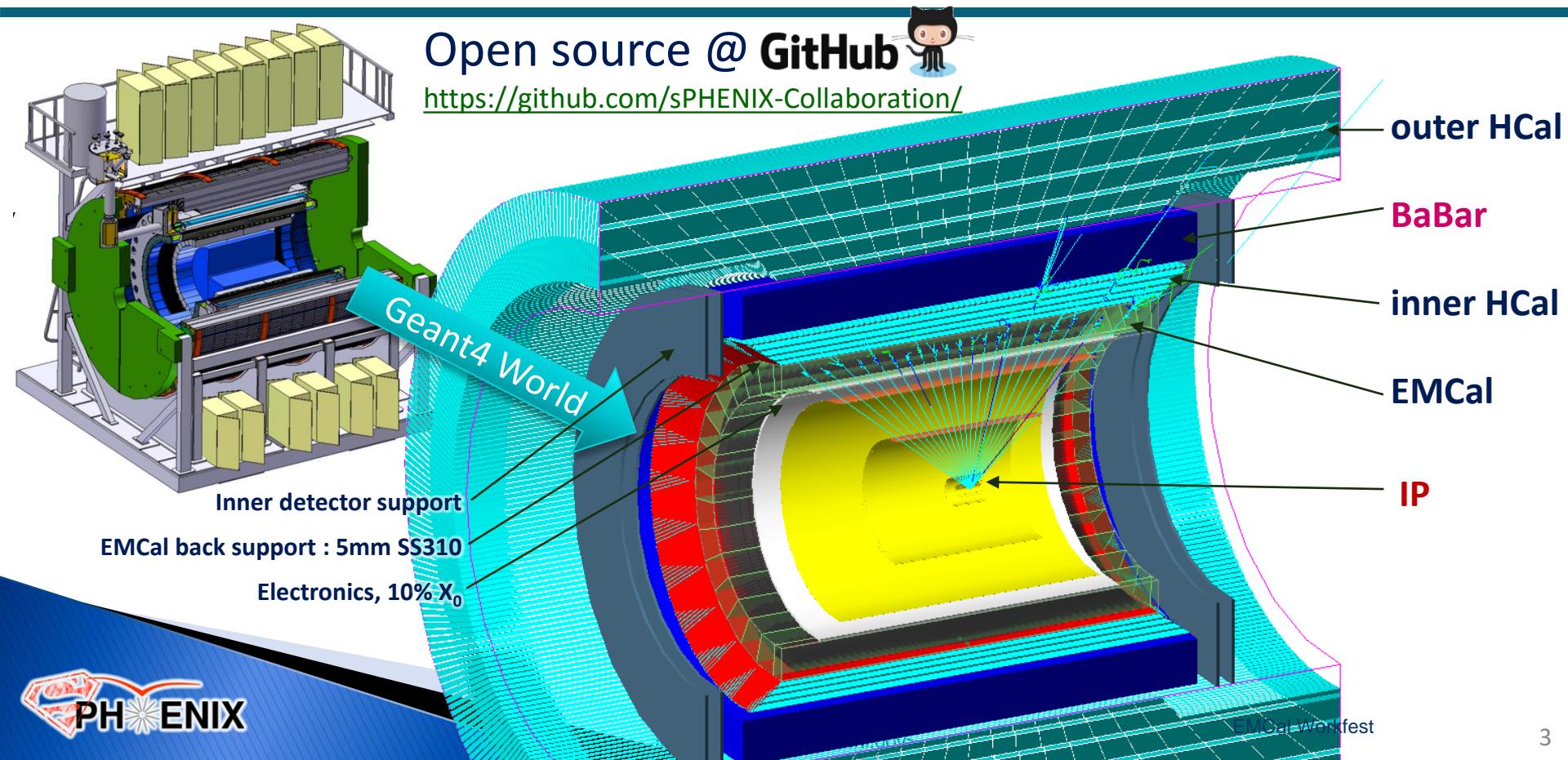
► One macro that does all

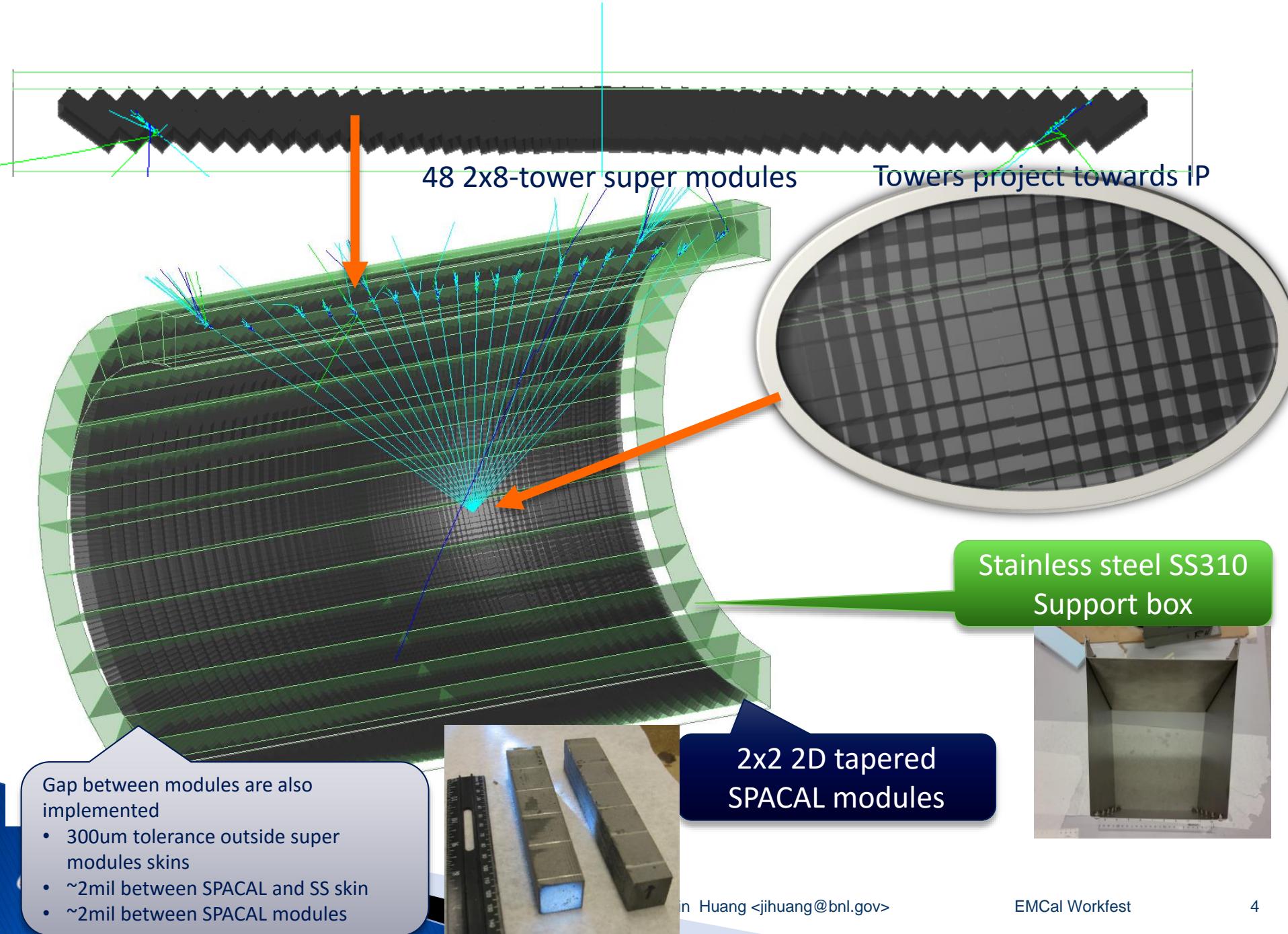
```
[jinhuang@rcas2073 test]$ git config --global http.proxy http://192.168.1.165:3128 #  
if this is first time you run git in your account  
[jinhuang@rcas2073 test]$ git clone https://github.com/sPHENIX-  
Collaboration/macros.git  
[jinhuang@rcas2073 test]$ cd macros/macros/prototype2/  
[jinhuang@rcas2072 prototype2]$ source /opt/sphenix/core/bin/sphenix_setup.csh -n  
# setup sPHENIX environment if not already done so  
[jinhuang@rcas2072 prototype2]$ root  
root [] .x Fun4All_G4_sPHENIX.C(-1) // sPHENIX simulation  
      .x Fun4All_G4_Prototype2.C(-1) // OR perform prototype simulation  
root [] .L DisplayOn.C  
root [] PHG4Reco* g4 = DisplayOn()  
root [] Fun4AllServer *se = Fun4AllServer::instance();  
root [] se->run(1)
```



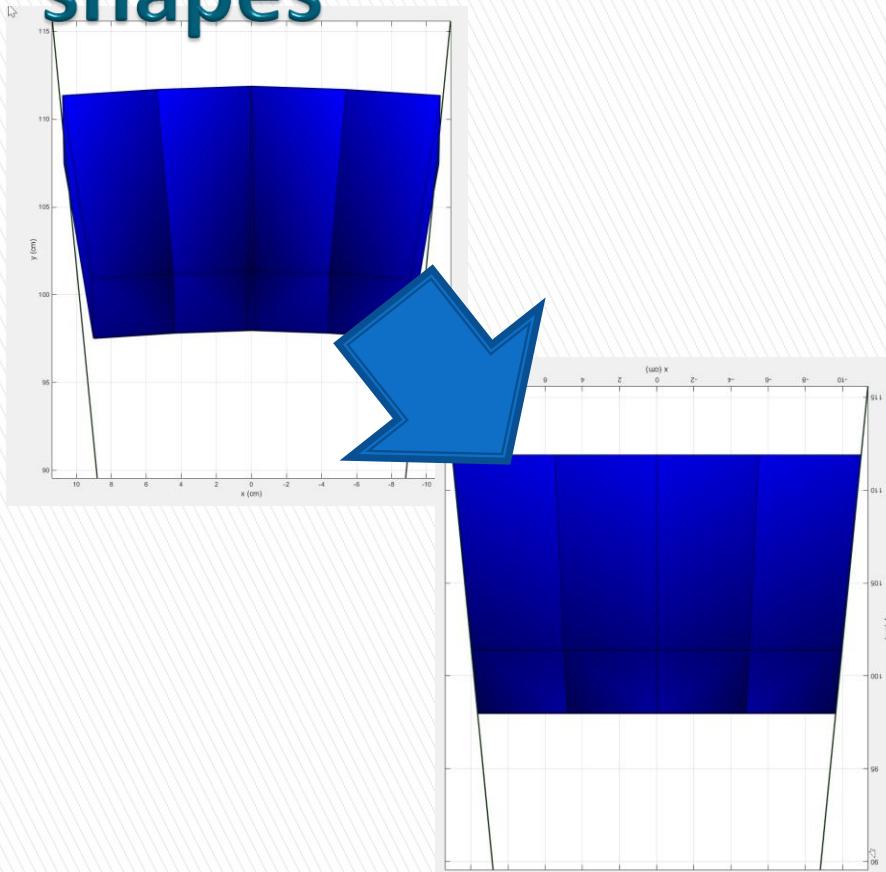
sPHENIX Calorimeters in Geant4

- EM calorimeter (EMCal) : $18 X_0$ SPACAL
- Inner hadron calorimeter (inner HCal) : $1 \lambda_0$ SS-Scint. sampling
- BaBar coil and cryostat. (BaBar): $1.4 X_0$ Coil & Cryostat
- Outer hadron calorimeter (outer HCal) : $4 \lambda_0$ SS-Scint. sampling

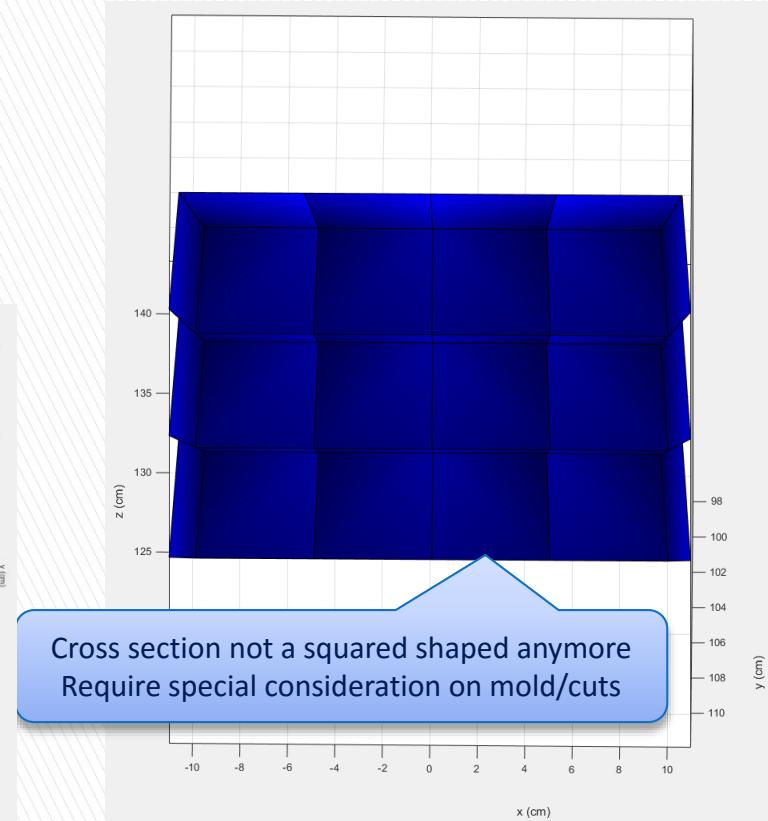




Detail view – adjustment of tower shapes

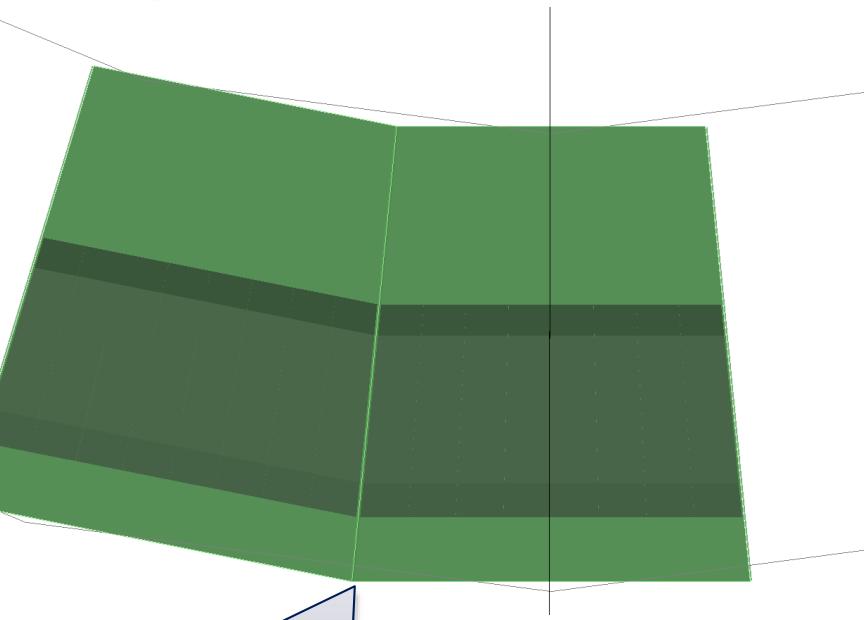


View from end



View from beam

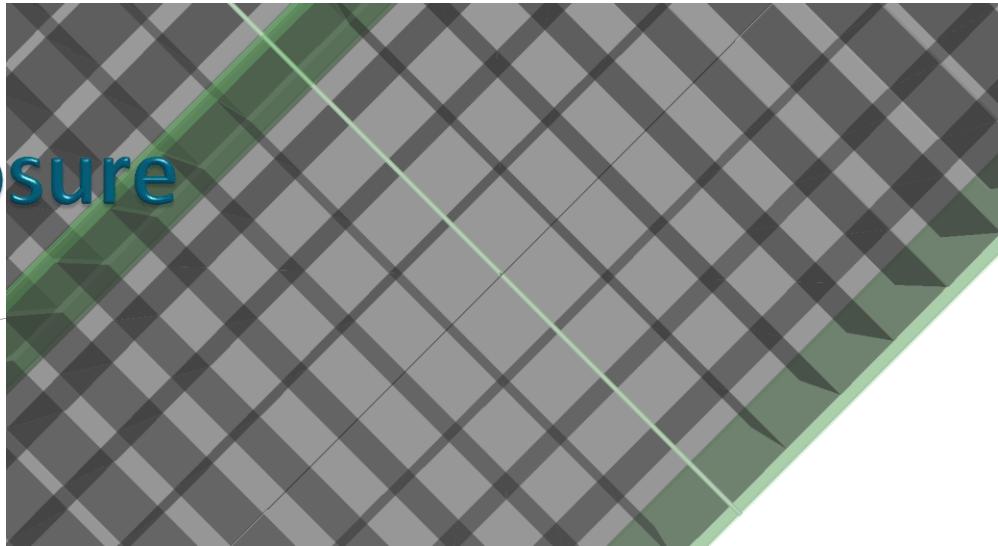
Detail view – super module enclosure



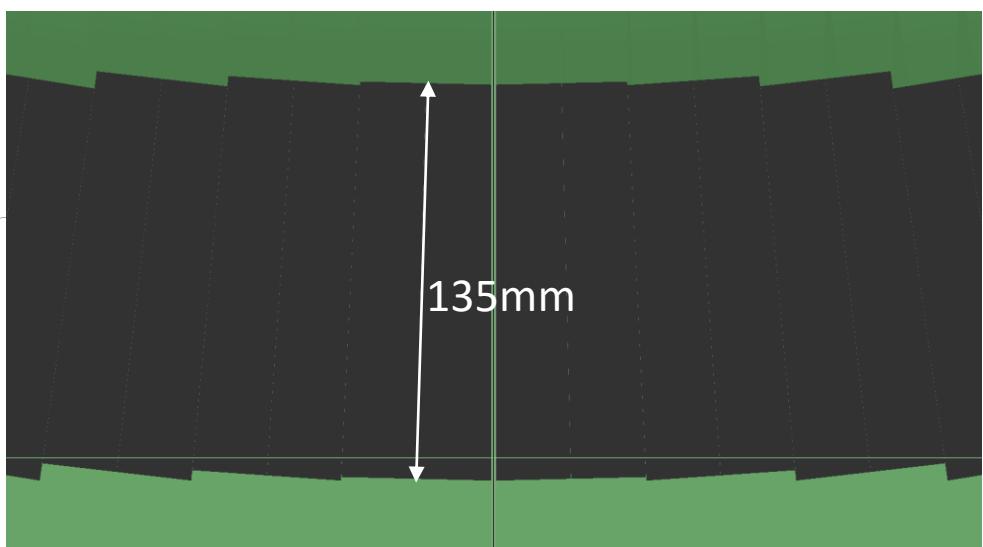
Side walls:

750um SS310 steel skin

300um tolerance outside super modules skins
(gap thickness = 600um)



135mm



end walls:

750um SS310 steel skin

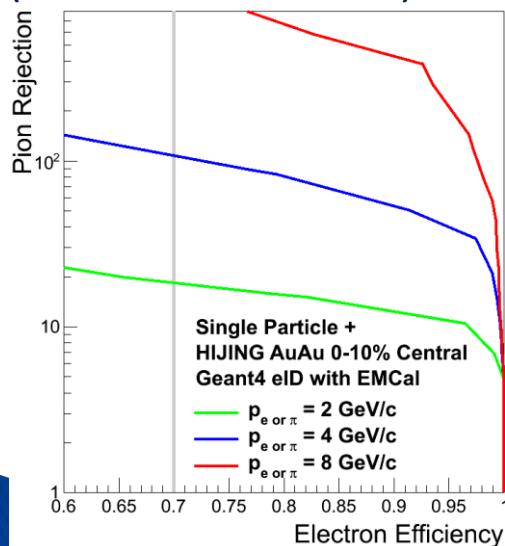
2mil tolerance outside super modules skins (gap thickness = 50um)

Physics Performance : electron-ID

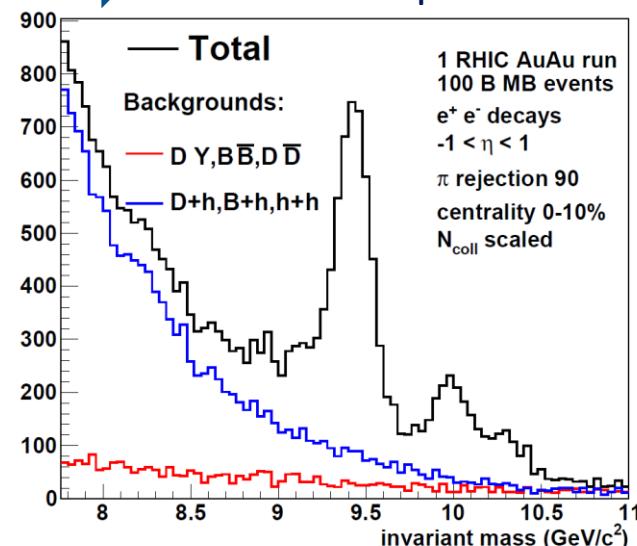
- ▶ Critical driving factor for EMCal design:
Upsilon electron ID & Triggering
- ▶ Baseline performance required 90:1 pion rej. @ 70% electron eff.
- ▶ Need to be revised again with full detector Geant4 sim with momentum dependency and revised background.
- ▶ Under update by Upsilon-topical group

Baseline EMCal performance + Baseline tracker performance → Satisfied the scientific goals

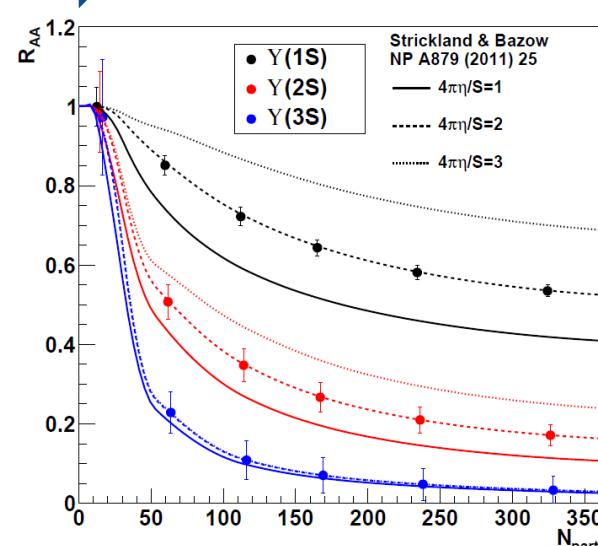
Hadron Rej. ~100:1 @ 4 GeV
(in central AuAu col.)



$\Delta m_{ee} = 100 \text{ MeV}$
Hadron VS Upsilon



Upsilon R_{AA}

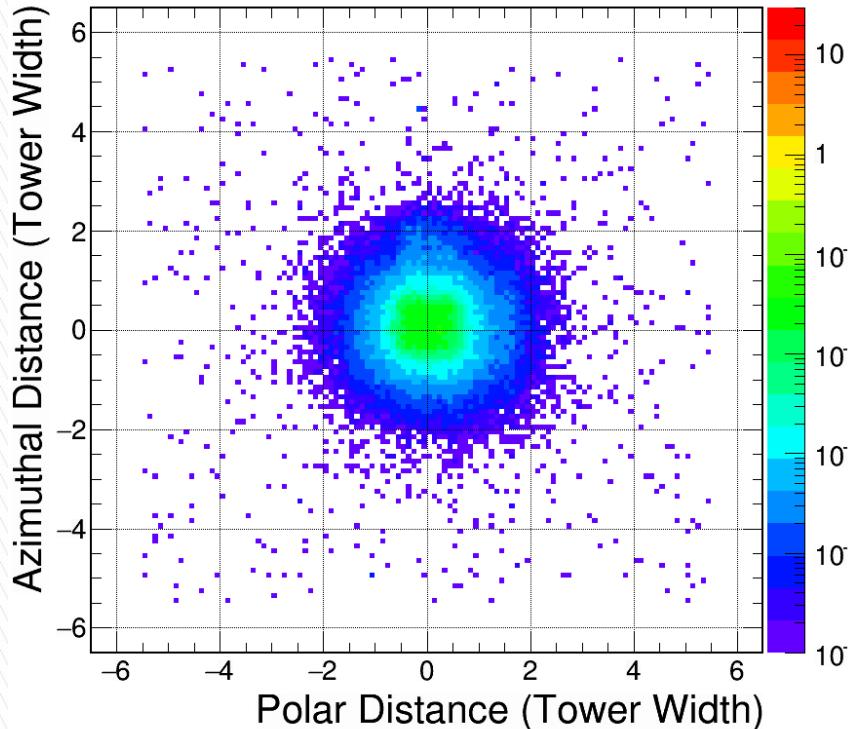


Other considerations in projectivity

- Safety factor to deliver Upsilon physics
- Pi-0 ID and calibration: require new clusterizer
- Soft-lepton tagging in jets: under study

Single e- 8 GeV shower in 1D/2D proj. SPACAL @ $\eta=0.9-1.0$

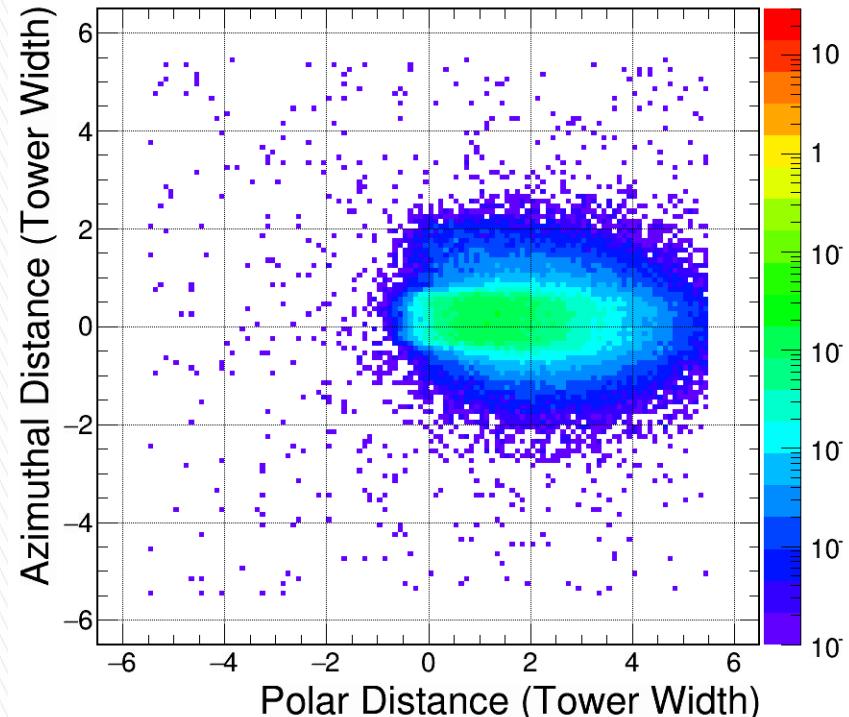
CEMC Tower Energy Distribution



2D projective SPCAL

Average cluster ~8 towers

CEMC Tower Energy Distribution

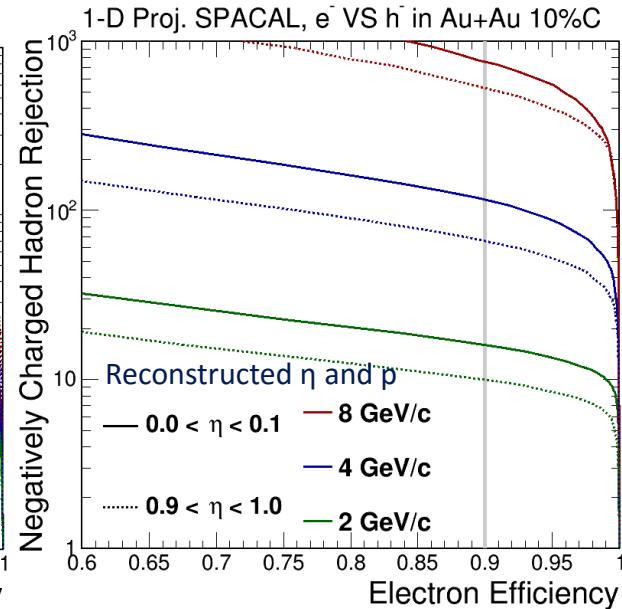
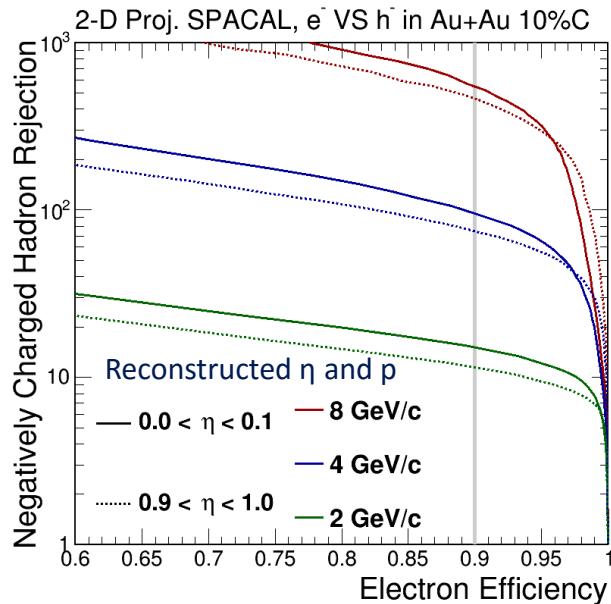
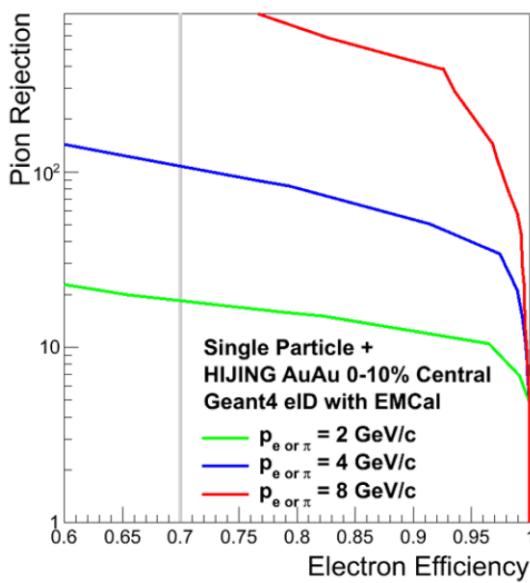


1D projective SPCAL

Average cluster ~12+ towers

Performance : electron-ID in Au+Au

Updated and more detailed simulation show good safety margin on electron-ID performance on top of the baseline design (as required to reach Upsilon program physics goal)



Baseline performance, design goals

- Sum all scintillator energy
- 1D SPACAL material with hits grouped into 2D SPACAL towers

2D projective SPACAL

- Updated studies (Preliminary)
- Sum all hadron taking account of hadron ratio
- Full digitization (w/ Birk corrections)
- Full tracking with silicon opt.
- Fully implemented 2D SPACAL (tower/support structure)

1D projective SPACAL

- Updated studies (Preliminary)
- Sum all hadron taking account of hadron ratio
- Full digitization (w/ Birk corrections)
- Full tracking with silicon opt.
- Ideally towered (no-tower boarder, no enclosure structure)

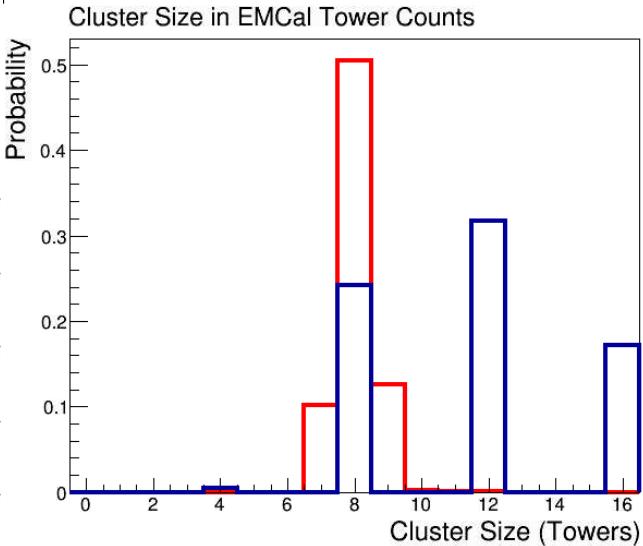
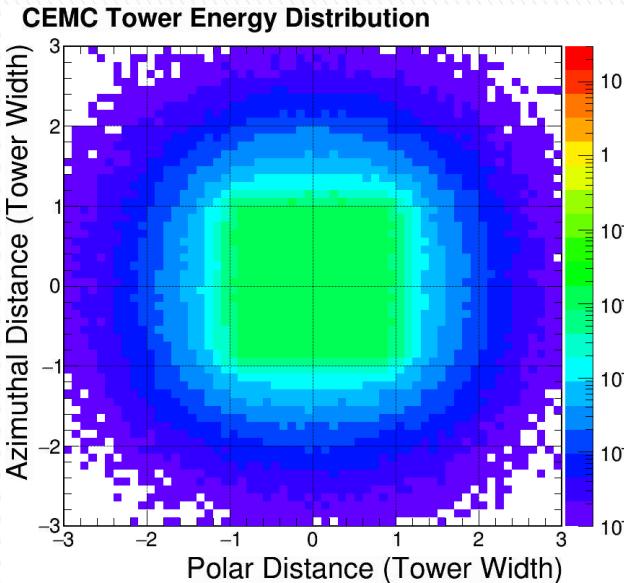
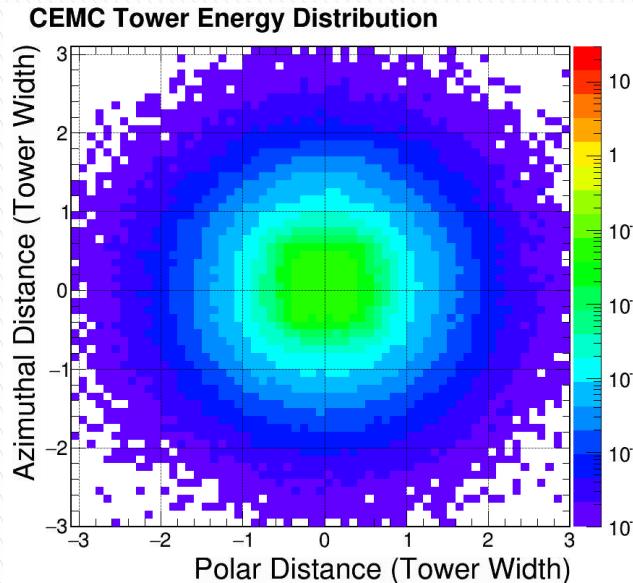
EM-Shower shape as observed in readout

8 GeV e- shower in 2D proj. SPACAL around eta = 0

Options available to simulate 2x2 ganging readout

Larger spread of shower core requires larger cluster to contain, which pickup higher portion of hadronic shower and higher event background

— Default
— 2x2 Ganging



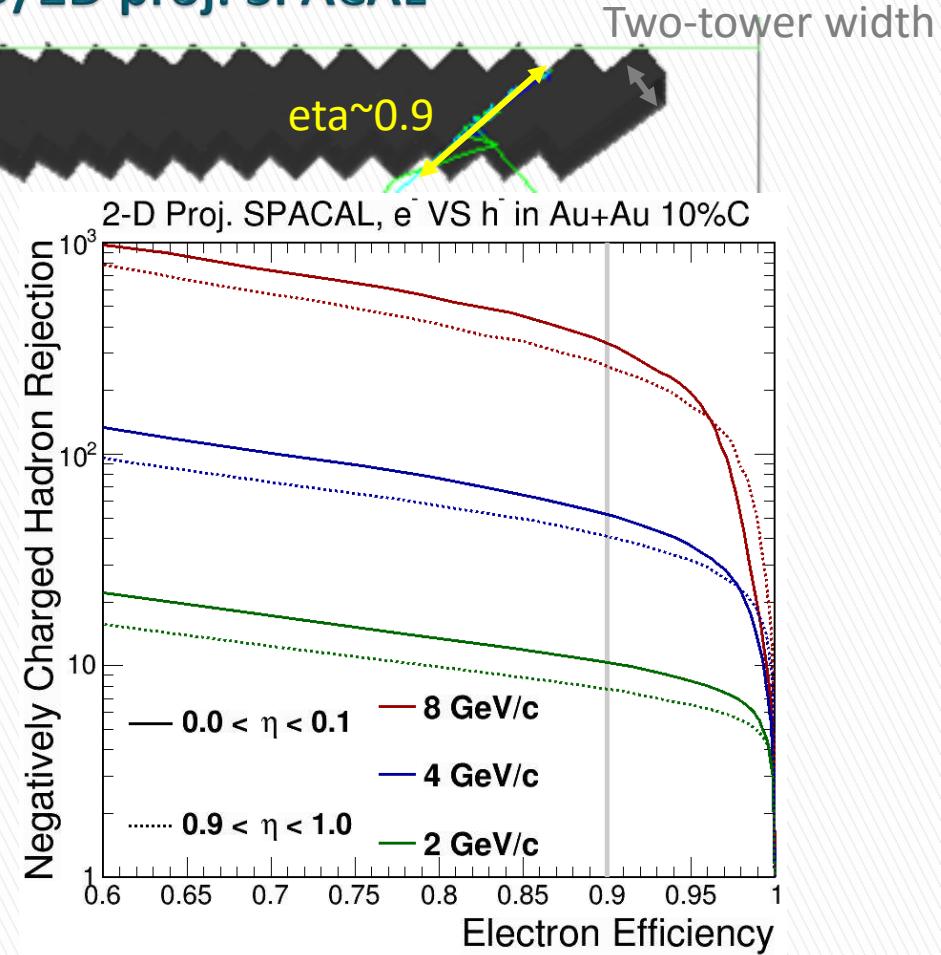
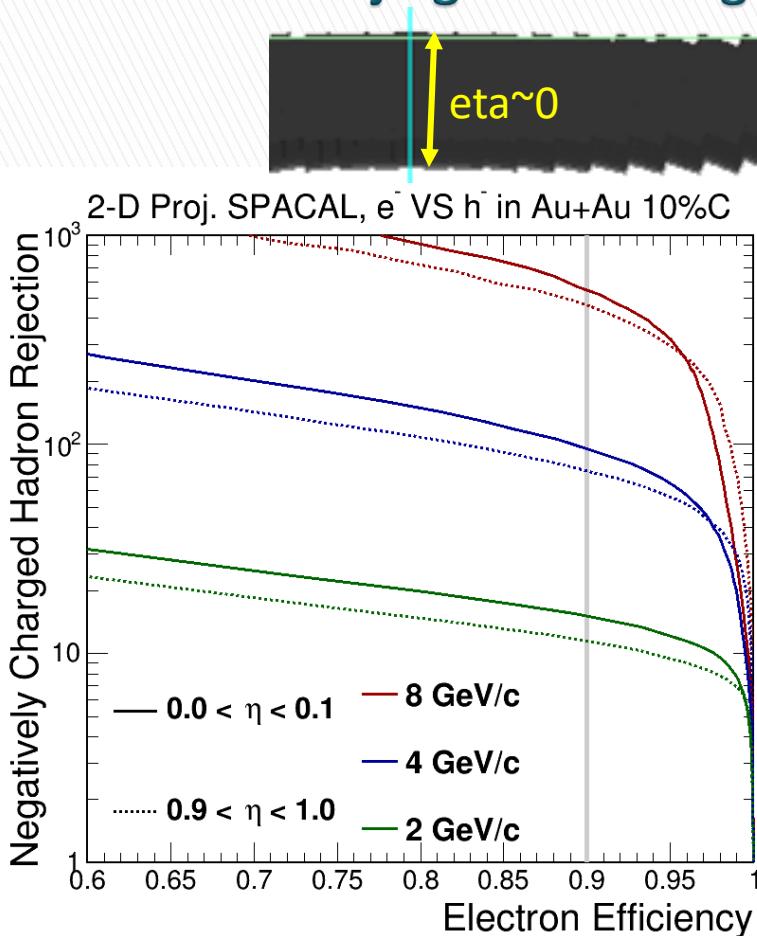
One readout per tower

One readout per 2x2 tower

Cluster size comparison

In Hijing -2D SPACAL summary: h-

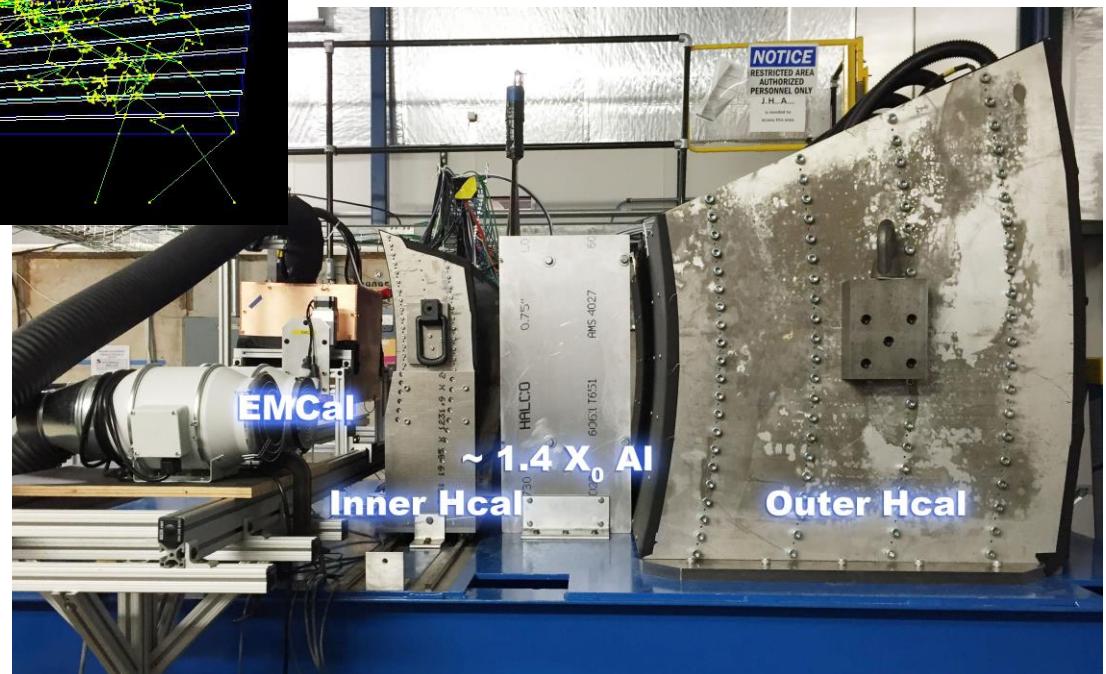
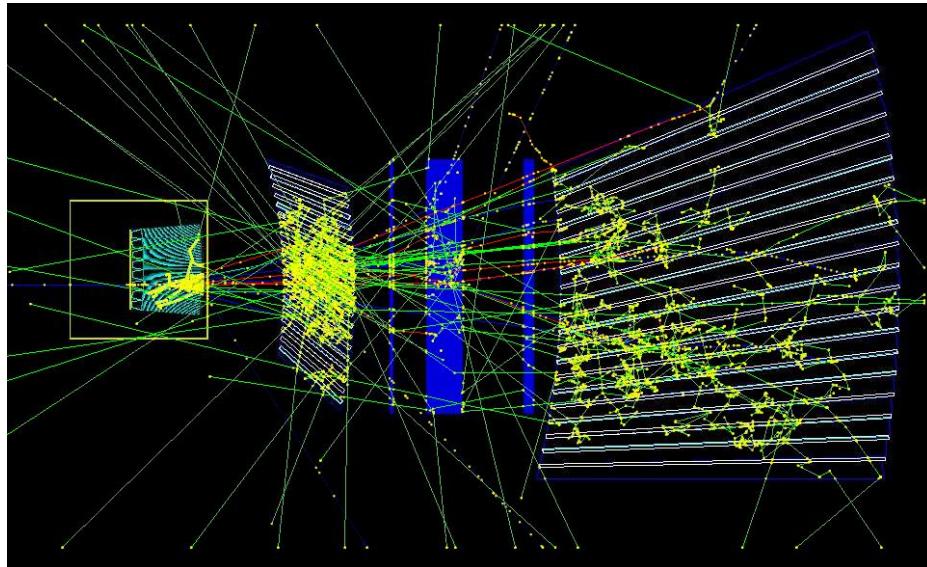
10% Central Hijing embedding in 1D/2D proj. SPACAL



One readout per tower

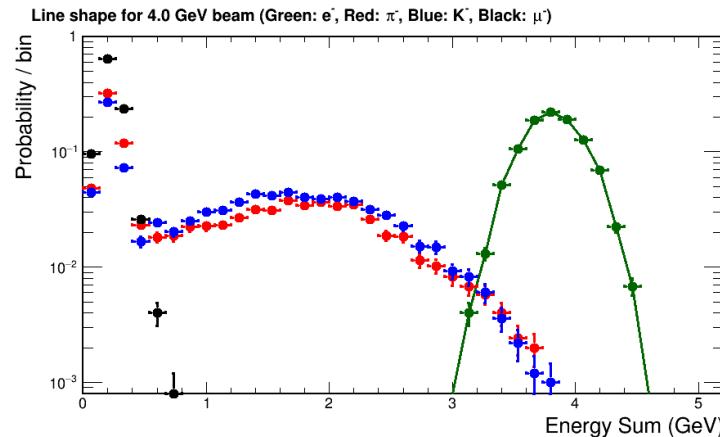
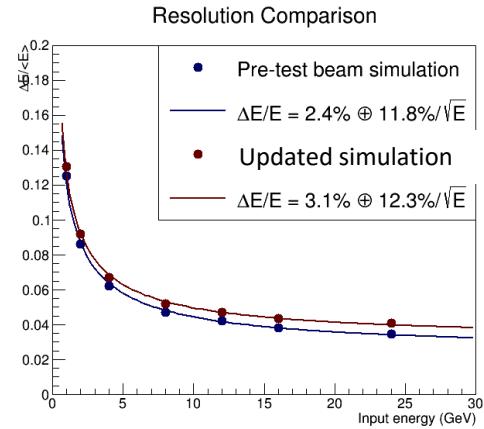
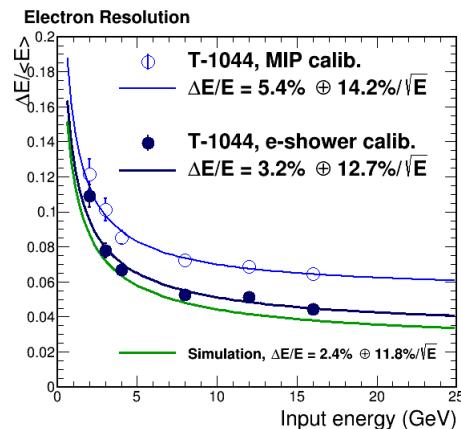
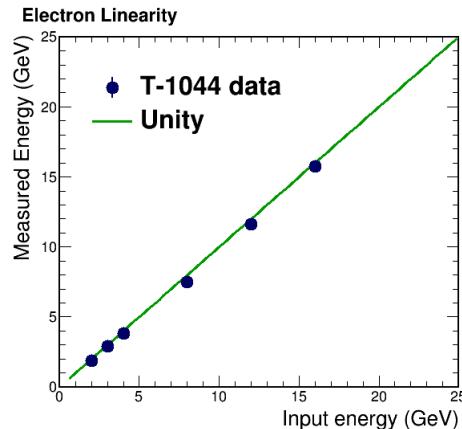
One readout per 2x2 tower
Cluster size x (1.2x1.2)

Next: Test beam simulation



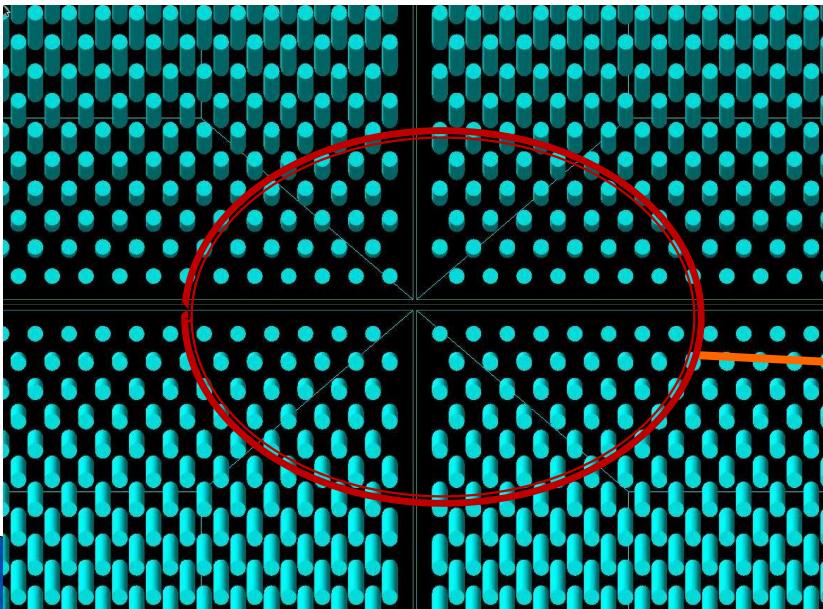
What we already have in SPACAL?

► Performance prediction for data



What we already have in SPACAL?

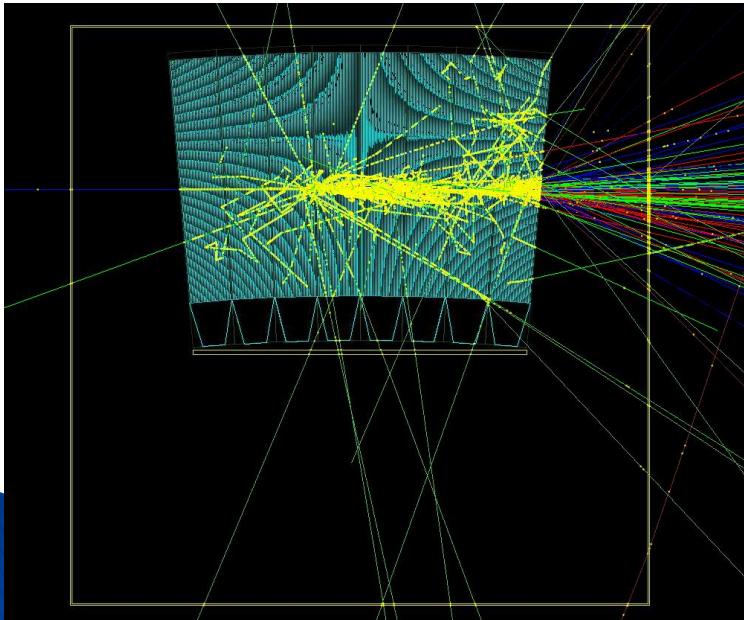
- ▶ Detailed modeling of fiber and assembly spacing
 - 18 mil W shell outside the fiber matrix due to machining residual
Is this realistic enough?
 - Diameter-470um fibers in 1mm triangle matrix and protective in the vertical direction
 - 0.1 mm horizontal assembly spacing
 - 0.33 mm vertical assembly spacing



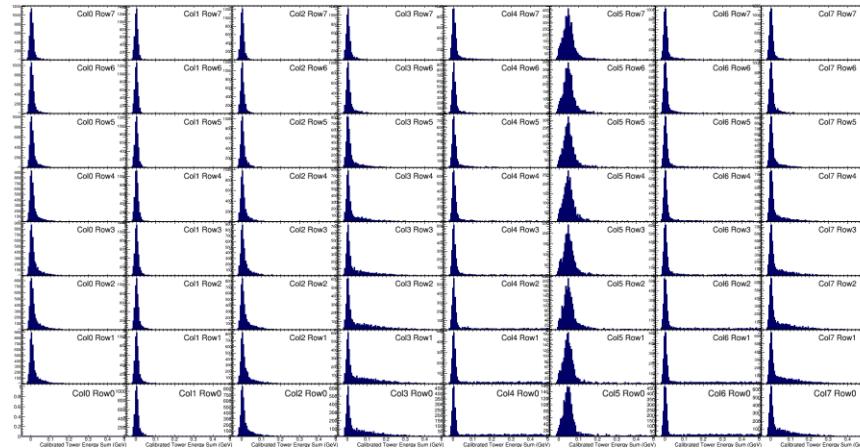
Sean Stoll (BNL)

What we already have in SPACAL?

- ▶ Test beam enclosure, light guide and electronics
- ▶ Free parameter to adjust position and rotation
- ▶ Digitization simulation with SiPM noise, convert to ADC amplitude, and calibration
- ▶ Save tower structure for calibrated tower as real data



Rotated to face down for 120 GeV proton calibration



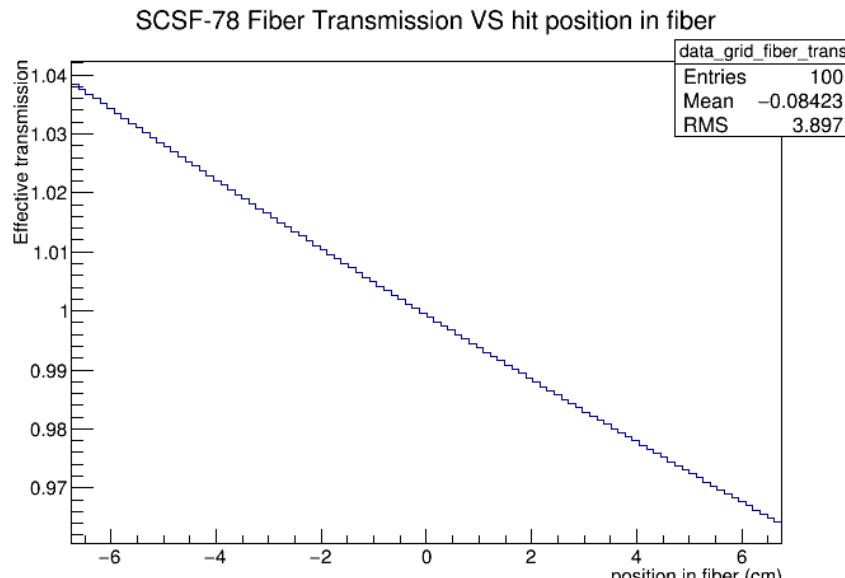
What we already have in SPACAL?

scintillator fiber model

- ▶ Utility introduced for any subsystem to easily fetch local coordinates:

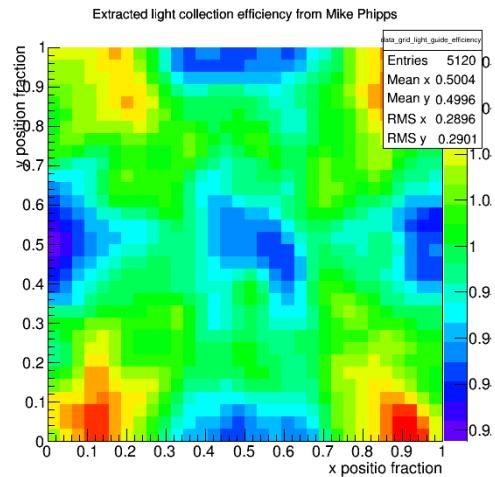
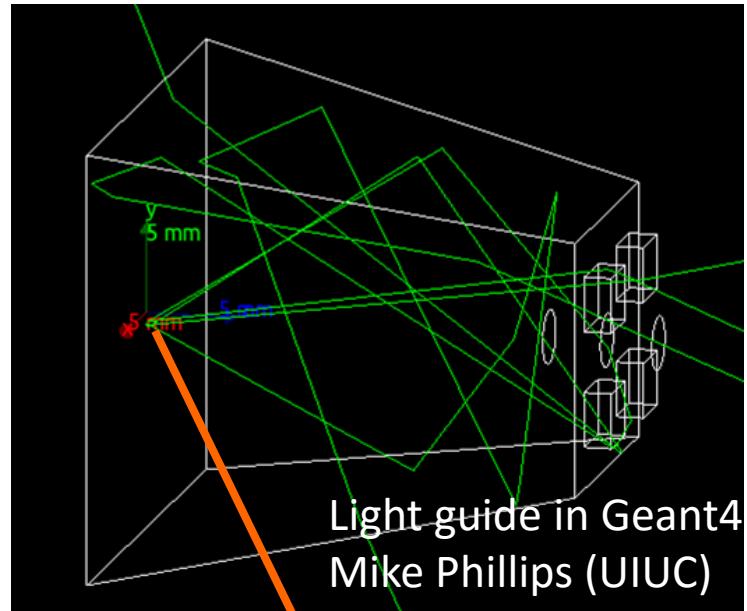
<https://github.com/sPHENIX-Collaboration/coresoftware/commit/ac9ae806aaa29d3c774830a16dfd4b0c3e694a91>

- ▶ Light attenuation and reflection in SPACAL fiber
 - SCSF-78 scintillation fiber spec: attenuation ~ 105 cm for short fiber
 - Reflector at the non-readout end: eff. $\sim 30\%$

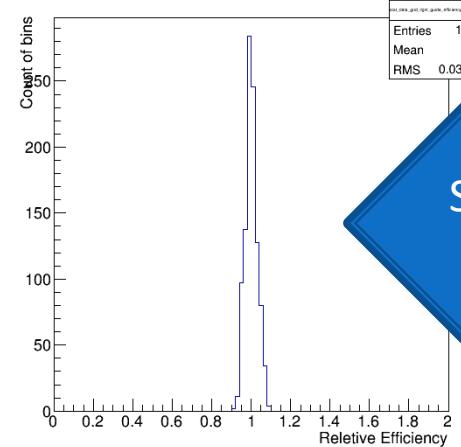


What we already have in SPACAL?

Light guide model

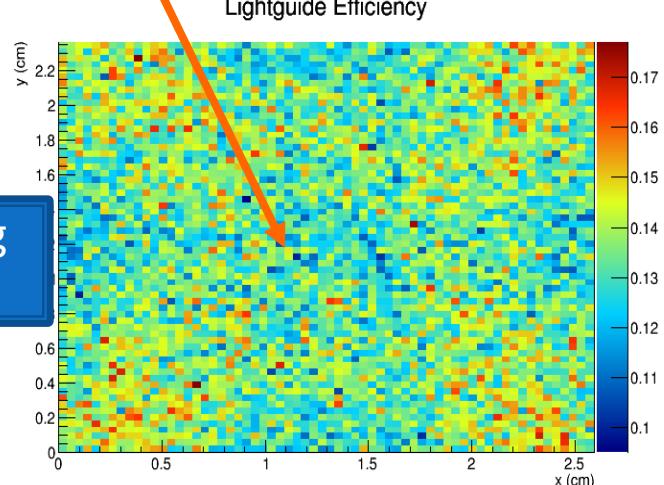


Efficiency statistics

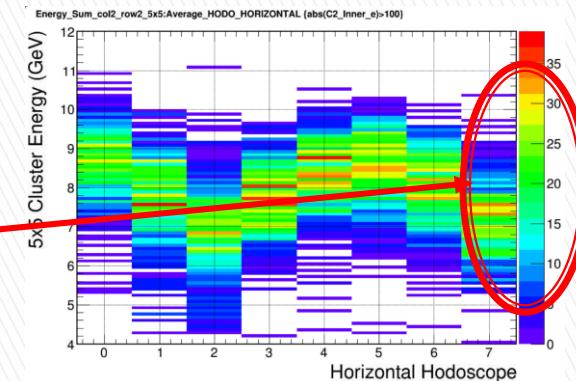
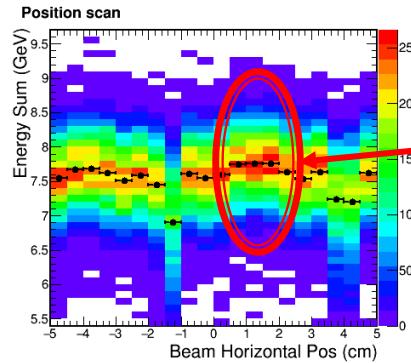
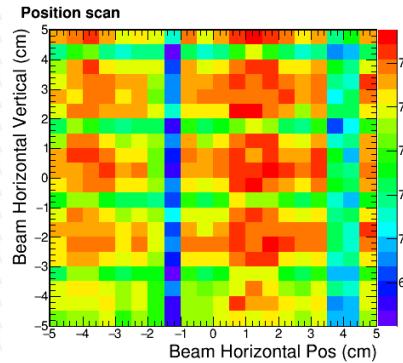


Smoothing
Rebin

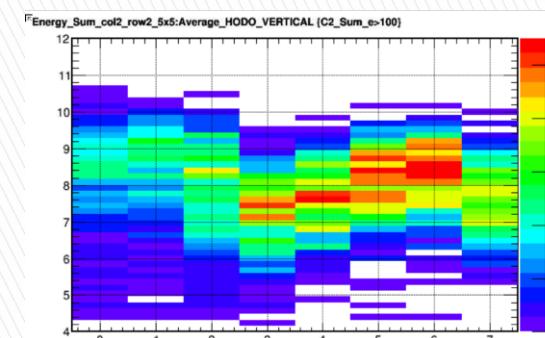
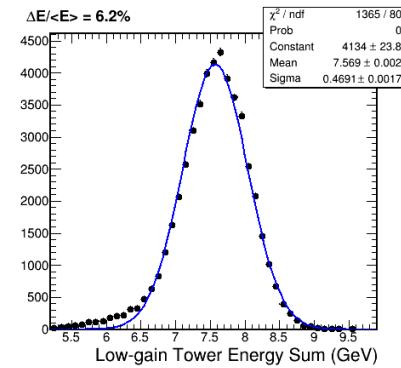
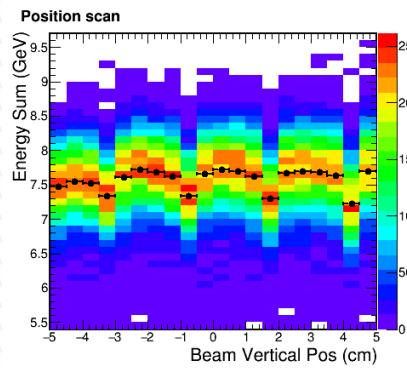
Huang <jihu



Position dependence: Sim VS data



Horizontal hodo-scope (0.5 mm/counter)



Vertical hodo-scope (0.5 mm/counter)

Simulation with simulated light guide collection eff.

T1044 Data
Run 2609, up tilt 5 degree, 8 GeV electron

Next ...

- ▶ Try Sean's measured light-collection map for light-guide
- ▶ Check consistency in boundary scans
- ▶ Update final plot to go with data
- ▶ Apply what we tuned to describe simulation data to full sPHENIX simulation
 - Hadronic package
 - Scintillation model
 - Light collection model
 - Gaps
 - Noise and discretization errors